AD-A118 841 ARMY WAR COLL CARLISLE BARRACKS PA F/G 5/4

A CONCEPTUAL DECISION METHODOLOGY FOR HIGH TECHNOLOGY TRANSFER --ETC(U)

MAY 82 D E CARR, W W COX, F A SHARP

UNCLASSIFIED NL

1 OF 1

AD A

118841

END

DATE FILMED

09-82

DTIC

MAY 1982

A CONCEPTUAL DECISION METHODOLOGY FOR HIGH TECHNOLOGY TRANSFER ASSESSMENT

by

COLONEL DONALD E. CARR, MS
COLONEL WILLIAM W. COX, SC
LIEUTENANT COLONEL FRED A. SHARP, SC

~~THE DISTRIBUTION OF THIS STUDY TO OTHER DOD ACTIVITIES DOES NOT CONSTITUTE RELEASE AUTHORITY. PURSUANT TO DOD DIR 5200.20, DISTRIBUTION [illegible] ... [illegible] EXPRESS APPROVAL OF THE US ARMY WAR COLLEGE.~~

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. A118841	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A Conceptual Decision Methodology for High Technology Transfer Assessment		5. TYPE OF REPORT & PERIOD COVERED Study Project
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Donald E. Carr, Colonel William W. Cox, Colonel Fred A. Sharp, Lieutenant Colonel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army War College Carlisle Barracks, PA 17013		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Same		12. REPORT DATE May 1982
		13. NUMBER OF PAGES 70
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Substantial controversy has occurred in nearly all United States policy decisions associated with high technology transfers to foreign countries. Some of the controversy occurs due to poor definition relevant to technology transfer concepts and terms. Still other controversy results from diffusion of the policy process among the many governmental agencies charged with review of high technology transfer decisions. The study hypothesizes that much of the controversy stems from lack of utilization of a common and consistent methodology for conceptualizing basic elements of decision processes

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Item 20. (Continued)

associated with high technology transfer cases. A decision concept or methodology is developed from classical decision theory which may assist in the resolution of conflicts associated with high technology transfer decisions. Utilization of the decision framework is demonstrated and indicates how policymakers may better focus their attention consistently on the critical elements of decisions and policy formulation involving high technology transfer.

USAWC MILITARY STUDIES PROGRAM PAPER

A CONCEPTUAL DECISION METHODOLOGY FOR HIGH TECHNOLOGY TRANSFER ASSESSMENT

A GROUP STUDY PROJECT

by

Colonel Donald E. Carr, MS
Colonel William W. Cox, SC
Lieutenant Colonel Fred A. Sharp, SC

Lieutenant Colonel Theodore J. Crackel, AR
Study Adviser

US Army War College
Carlisle Barracks, Pennsylvania 17013
14 May 1982

AUTHOR(S): Donald E. Carr, COL, MS
William W. Cox, COL, SC
Theodore J. Crackel, LTC, AR
Fred A. Sharp, LTC, SC

TITLE: A Conceptual Decision Methodology for High Technology Assessment

FORMAT: Group Study Project
DATE: 14 May 1981 **PAGES:** 70 **CLASSIFICATION:** Unclassified

Substantial controversy has occurred in nearly all United States policy decisions associated with high technology transfers to foreign countries. Some of the controversy occurs due to poor definition relevant to technology transfer concepts and terms. Still other controversy results from diffusion of the policy process among the many governmental agencies charged with review of high technology transfer decisions. The study hypothesizes that much of the controversy stems from lack of utilization of a common and consistent methodology for conceptualizing basic elements of decision processes associated with high technology transfer cases. A decision concept or methodology is developed from classical decision theory which may assist in the resolution of conflicts associated with high technology transfer decisions. Utilization of the decision framework is demonstrated and indicates how policymakers may better focus their attention consistently on the critical elements of decisions and policy formulation involving high technology transfer.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

United States dominance in innovation, research investment, and technological development has had significant impact on shaping foreign opinion and perception of our leadership position in world affairs.

Today because of the constraints on resources and extreme high cost of equipment and maintaining a military force capable of reacting to a global commitment, technology has taken on an even more important role. An influence that goes far beyond national security into economic tradeoffs and foreign policy.

Technology transfer has different meanings to each person using the term. It includes everything from pure scientific research to sophisticated equipment. Today, there are numerous definitions for technology transfer being used (4, p. 15; 3, p. 4; 1, p. 1; 7, p. 13). Most suggest that if you transfer equipment you have transferred the technology, in the narrow view what is transferred is neither a product nor a service but the results of the use of technology (8, p. 23). Technology, then, is the application of science to the know-how and manufacture of a product. There is no technology transfer unless the receiver has the specific know-how required to define a product, design a product, and to manufacture it. The implication of a transfer goes beyond the immediate product involved and must consider other applications of the technology (2, p. 28).

This confusion as to the definition of technology transfer and governmental control has clouded the elements of the decision process making it almost ineffectual. The Comptroller General states the situation plainly: "The government does not have an effective policymaking structure to

reconcile the conflicting goals of export promotion and control of technology. On top of these problems, the decision process is characterized by delay, uncertainty, and lack of accountability."

Further, control and decisions are compounded by our freedom in publication, availability of technical data, international joint enterprises or co-production agreements, multinational corporations, weapon sales, foreign students, and yes even espionage.

The government ideally tries to avoid measures that give special incentives or disincentives to free enterprise and normally does not interfere in the activities of individual companies regarding international trade. This principle of non-interference flows from our longstanding commitment to a generally open international economic system, and to a considerable extent it covers the transfer of technology (8, p. 15).

As a nation, new technologies and technology transfer creates a paradox for us. On the one hand they provide us the means to be a great power and provide capabilities to our citizens that far exceed the rest of the world. On the other hand it enables us as a great nation to assist the lesser developed nations of the world which complicates and handicaps our ability to clearly see the goals we should be striving to reach. Considering the interrelationships and tradeoffs required to balance the benefits between national security, economics, foreign policy and scientific exchange, a decision process is essential to bring together the concerns of government, protect industry and technical institutions (9, p. G11). This complexity causes the need for a decision to move through a myriad of controls and regulatory policy.

Technology transfer regulatory policy originates from five statutes

that cover export administration, security assistance, nuclear non-proliferation, arms export and atomic energy. These are administered by the Departments of Commerce, State, and Defense and by the National Security Council. As can be seen, the players in government are many and the regulations generally lacking, which places constraints on the review and a question as to the validity of the decision.

National security implications when considering a product or process for transfer involves consideration of the following: the capabilities of the technology itself; the nature of the transfer mechanism; the character of the recipient environment, including infrastructure capabilities; the relative technological capabilities of the seller and the recipient; the available deterrents to diversion of end use; the priorities and intentions of the recipient; and the character and volume of related purchases in the past. Determination of the motives and probably behavior of potential adversaries, for instance, are judgemental and can never wholly account for the impact of unforseen events or priorities--and this means virtually all critical high technology transfer entails some degree of risk which the best guarantees or decision processes cannot eliminate (5, p. 11).

Measurements are difficult as we can see by the above considerations; however, there are criteria that can be evaluated against case studies provided their object and scope are clearly defined (10, p. 67).

To benefit the military strategic planners and decision-makers, the development of a risk assessment decision model which would assist in evaluating decision alternatives related to critical high technology transfer as it impacts national security is necessitated. This study indicates the degree to which classical decision theory may be relevant.

It may assist the policy and decision formulators concerning critical high technology decisions as it pertains to risk environments in national security and its possible application to foreign policy and economic decisions.

Dr. Fedoseyev, a Soviet defector, sounds the alarm for action when he said, "It is absolutely impossible to struggle with such a system of technology transfer by means of the decentralized system of responsibility and lines of decision-making existing in the United States. A central organization and process in the United States would be required" (6, p. 7). Dr. Fedoseyev is a native of Russia, born in 1910 and educated as an engineer. He is undeniably an expert in selected engineering technology fields and has experienced the results of technology transfer from the United States.

Now is the time when our high level decision makers must have available a simple decision methodology that will assess risk and provide the net benefits among the varied decision alternatives associated with a potential critical high technology transfer.

CHAPTER II

TECHNOLOGY TRANSFER REGULATORY PROCESS

THE GENERAL SETTING

The control problems of technology transfer cannot be solved quickly. Regulatory controls over the course of years have been used to achieve a multitude of objectives, some good, some not so good. The effectiveness of technology transfer depends not only on what is transferred and how, but also on the capacity of the country receiving it, their ability to absorb and put it to work for their benefit. Technology transfer, as indicated, i essentially not necessarily a product, but know-how. In terms of national security there is more than just military factors involved in the decision and regulatory process, as one looks at the effects of the transfer and how it may impact on the national security of the United States, other factors become evident.

Both the political and economic factors are very relevant in the relationship of judging a proposed transfer of technology to another country. The tendency has also been, in the past and even to some degree today, to separate technology regulatory controls into specific areas (i.e. national security, foreign policy, etc.). When this occurs the distinction on which high level decision or policy is based tends to become blurred and no simple management procedure has yet been developed which can resolve the conflicting viewpoints which often arise, other than a decision at the highest level (2, p. 410).

An understanding of the environment which affects the control process

on technology and technology transfer requires an appreciation of what has been labeled "the technology diffusion process." "The process of technology diffusion begins with applied research which generates a technology to satisfy a need or to exploit an opportunity, and continues through the adoption and application of the technology" (7, p. 1). Today as in the past this technology diffusion process has impacted on the activities of private business, federal and state government, and the individual agencies within the state and federal government who attempt to understand and control it, as well as on U.S. interest abroad.

In the present era of technology competition, both within the private sector of the United States and the international arena, the federal agencies charged with the responsibility to control the flow of critical technologies are up against stiff competition, both within the United States and Third World countries, with the Soviet Union being one of the chief competitors.

This competition in high technological areas with the Soviet Union goes back to WW II when the Soviets began their independent efforts to develop an atomic bomb and has been a continued effort on their part ever since (9, p.1). They have often stated their goal of superiority in science and technology with their present and near-term military capability. They have reflected steady growth and achievements of a high priority military research and development effort and an expanded highly developed technology base second to none (14, p. 2). The source of much of the high technologies which has and is still assisting the Soviets to push ahead is the industrialized Free World, with the United States showing signs of perishability with regard to its technological edge which it has relied upon to counter the

Soviet military superiority in numbers of men and weapons.

In addition, the Soviets have been supplied with billions of dollars worth of U.S. industrial machine tools, transfer lines, chemical plants, precision instrumentation, and associated technologies. Unquestionably, these technologies have played a major role in the modernization and expansion of the Soviet industrial complex. The exact improvement in military capabilities brought about through the acquisition of Western technology is difficult to quantify; however, Western built plants in the Soviet Union now produce truck tires which possess one-third greater wear because of superior carbon black, aircraft engines which suffer less down time, and more efficient trucks--all made available from Western turn-key plants. Other high visible items include IBM 360 and 370 computers whcih were illegally diverted to the Soviets in 1971 and 1972 and have been the cornerstone for the Soviet Warsaw Pact de opment of the RYAD I and II computers (14, p. 9-10). More recen , in 1978 the United States approved the sale of a turn-key plant wit e capability of producing unique deep oil drilling bits (5, p. 6) That same plant which provided the technology leap for the development of high grade tungsten carbide also provided the know-how for the Soviets to manufacture armor-penetrating projectiles (2, p. 413-414). It also had computer technology with the capability of controlling electron-beam welding equipment, which has both nuclear and laser aircraft production applications (5, p. 6).

These examples are but a few with respect to technology and technology transfer which have helped the Soviet Union to press ahead in their efforts to expand their high technology military industrial complex. They reflect also the diversion of sources of technology transfer and their impact.

Once a technology has been transferred, there is no effective control of either the subsequent flow of products or the future applications of the technology--it is at that point an irreversible technology transfer decision (3, p. 4). Top Soviet leaders continue to be keenly attuned to the potential of Western science and technology for the future of the Soviet Union (8, p. 69).

THE INSTITUTIONAL FRAMEWORK

Within the federal government today the principal legal basis for U.S. regulatory policy concerning export control of technology is found in five statutes: The Export Administration Act; The International Security Assistance Act; The Nuclear Non-Proliferation Act; The Arms Export Control Act; and The Atomic Energy Act. The key export control structure involves the Department of State, the Department of Commerce, the Department of Defense, and the National Security Council. Each has a part to play in the control process of technology transfer and each has developed interagency organizations to carry out their responsibilities. These organizations have resulted in a somewhat slow and complex structure often with lack of specific direction and coordinated urgency on key issues. The regulations which they are tasked to use are lengthy, detailed, complicated and in some cases not very current. Technical expertise within the government is also scarce in this vital area and with the current constraints often is not available. This makes the job even harder for those tasked to review and provide input within given time periods on selected technologies.

The basic industrial export control mechanism continues to be centered in the Department of Commerce, with the Office of Export Administration

(OEA) providing over-all responsibility for export licensing of industrial products and technical data. In performing their task of reviewing and acting on formal applications, OEA coordinates with all other interested agencies, using the critical control list of high technologies developed and approved within the framework of the federal agencies involved. Applications are staffed and reviewed at operating committee level which consist of staff members from Defense, State, OEA and other interested agencies. When issues cannot be resolved, selected applications may be referred to the Advisory Committee on Export Policy which meets at the Assistant Secretary level. Should disagreement still persist, it will go higher to the Secretary level for resolution, and finally in those cases which involve critical issues of technology transfer which may impact on national security, Presidential decisions are often required (8, p. 26). Although a system exists, it would be inaccurate to say that a consistent rationale motivates or guides the actual administration of all U.S. export controls within the government.

While the Department of Commerce is the center of the export control system, it is by no means predominate in the control of all exports. True, it is a key player, just as the Department of State and the Defense Department are key players with each having input and responsibilities within their own areas. The Department of State is charged with the responsibilities for licensing exports of arms, ammunitions, implements of war and related technical data. Within the State Department organizations have been established to administer this licensing responsibility and to participate in other technology control activities requiring representation from the State Department. Sometimes one department's responsibilities overlap

those of another, causing delays and in-house disagreements within the government. In actuality each is evaluating the same thing but from different reference points. The Department of State controls military items and information that may have commercial implications, and the Department of Commerce reviews commercial products that may also have military uses (8, p. 28).

The Defense Department also plays a key role in the review of validated export licenses. In 1977 Congress took action and strengthened the role of the Department of Defense in export control. By amendments to the export control legislation, what had once been "routine" validated applications must now be reviewed by the Department of Defense. The Department of Defense has thirty days to review and recommend action to the President. Should the President overrule them, then he has thirty days to submit an explanation to Congress. These changes increased the review time and clearly displeased the industrial groups who also have representatives participating in the export licensing process. Although these representatives have no policy role they sit on technical advisory committees and provide technical input for the review process (8, p. 27-28). Even though they are fully aware of the primary objectives of the Department of Defense in the control of U.S. technology, which is insuring that the U.S. protects its lead time relative to its principal adversaries in the application of technology to military capabilities, they continue to promote less control and more vigorous exports of the industrial capabilities of the United States. With the growing economic competition on the world markets and the confusion that has a tendency to exist regarding regulatory procedures within the government, pressure is a continuous thing from the private sector on those who

must make decisions in the area of export licensing and technology transfer.

To fully appreciate the dilemna that surrounds the regulatory process, technology transfer and the decision environment which exists today on critical items of technology, one must keep in mind the type of government we have, the interest groups involved, the political issues which arise, our national security needs, the multitude of regulations and agencies involved, as well as the multifacets of technical expertise required to review an issue. Depending upon the particular issue, the level of involvement, the agency responsible, the political administration in office and the emphasis on the area often determine the priority of the process and the outcome. In theory the justification of this system is to protect U.S. national security interest.

THE INTERNATIONAL DIMENSION

As each responsible agency within the federal government is charged with certain responsibilities regarding control of key technologies and as they attempt to refine the internal procedures used to safeguard those identified as critical, another problem remains--this one deals with the international regulatory agency COCOM--the Coordinating Committee for East-West Trade Policy. This multinational consultative group on export controls was formed in 1949 to ban sales of goods of strategic military value to all Communist powers. It was concerned with both economic and security issues and adopted the U.S. concept of what constituted strategic items and how they should be controlled (6, p. 51).

The federal government has little freedom to change COCOM procedures.

In fact, many of our allies are extremely sensitive on the whole issue of COCOM (13, p. 22). In addition, other difficulties also exist in the COCOM process. Not all of our allies are members and Western Europe and Japan have never fully even agreed with our concept of COCOM's primary function. Historically, the U.S. has provided a much more extensive list of items to go on the COCOM list of banned sale items than our allies have been willing to accept. Disputes have followed and consequently technologies have been transferred which the U.S. did not support. However, items to be controlled are put on the list, reviewed and revised periodically and they provide the basis for national export controls. Decisions on given items are by unanimous vote, although an individual member may override a COCOM veto on a particular transfer if they judge the transaction to be essential to that country's interests. This does not happen frequently. The controls exercised by the U.S. and other members are designed primarily to withhold military significant exports to Communist countries; however, the effectiveness of the controls depend on the resources applied to the task of enforcement by all countries concerned. The flow of technology has not been stopped, but the primary objective of slowing down the rate of transfer of military technology is being recognized (11, p. 23-24).

Regardless of the controls and criteria employed, the U.S. continues to run into problems of technology transfer in the international arena. As Mr. Bucy stated in his article "On Strategic Technology Transfer to the Soviet Union":

> There is no formal COCOM control over the flow of technology from neutral to Communist countries. Of increasing concern is the assimilation of some militarily significant technology by the neutral nations of Western Europe--particularly Switzerland, Sweden and Austria--

> and the acquisition of such know-how by the countries of the Middle East (4, p. 35).

It is hoped that more effective multilateral controls can be imposed, thus protecting sensitive technologies while not reducing U.S. manufacturers' capabilities to compete on the world trade market. Recognizing this fact, we must also remember that our quality of life may depend upon foreign trade; however, our existence as a nation depends upon our national security. The continued outflow of U.S. technology has given rise to a gamut of complex issues relating to national security, foreign policy, international trade, foreign competition, domestic employment, and market access. Against this backdrop has arisen a divergence of views concerning the direction of future U.S. technology export policies and current practices. The tenor arising reflects concern with the present capabilities and the action being taken to correct the situation (6, p. 55).

IN SUMMARY--THE DILEMMA

Although the basic form and control of technology transfer is set forth in federal government legislation and to some degree in international agreements, there are those that doubt the machinery is capable of making the many refined decisions required to manage or control this multifaceted resource. To quote a 1979 American Enterprise Institute analyses:

> The (U.S.) Government does not have an effective policy making structure to reconcile the conflicting goals of export promotion and export control. Further, the decision making apparatus for determining what technology or products should be controlled is unwieldy and time consuming. On top of these problems, the export licensing system is characterized by delay, uncertainty, and lack of accountability (1, p. 1).

Different federal agencies have different viewpoints on what actions or

decisions may best serve our security interests. Upon close analysis of the interagency arrangements one might find it difficult to detect a high level of commonality in the decision criteria used within the complex review process--each provides a viewpoint arrived at from their own internal scope of the risk assessment as they see it regarding a particular transfer action. A coordinated decision methodology within the overall process is lacking and although unanimous participation appears to be provided for in the total framework of the regulatory process, a simplified technique needed for cohesion is not apparent. Top decision makers at Commerce, Defense, and State are still faced with diversified viewpoints without a common decision criteria in a confused, complex and often, time-sensitive area. This seems to be a major deficiency and one which could be approached using elements of the classical decision theory. How to refine internal decision making procedures so that national security is used in its broadest concept in the decision making process of critical technology transfer (12, p. 18).

It must be recognized that technology transfer is indeed a multifacted area and can not be bottled-up and controlled indefinitely. In time it will spread through one form or another; however, prior to its spreading, a sense of timing is essential to derive significant advantages from it. Decisions on critical technology transfer must be calculated around the products and their uses, considering the time advantages in delay of the transfer. Risks must also be calculated as they are reviewed across the spectrum of our national interest with the burden of decision hinging on our national security interest. The impact on foreign trade, international political relations, economic growth and development of friendly countries are also all variables which are part of the overall decision equation.

Science and technology has made the U.S. a world leader; that same science and technology must now be reviewed and decisions made on the risk of transferring selected critical capabilities to our adversaries. Technology, interwoven with the economic, political, and security interests, is far from neutral and the crux of the problem may not be control, but better management of the technology transfer process within the time constraints which are recognized as critical (10, p. 7-8).

CHAPTER III

HIGH TECHNOLOGY TRANSFER DECISION METHODOLOGY

Recently much interest has been focused on the decision processes related to high technology transfer and the impact of transfer decisions upon vital U.S. national interests. One needs only to review the recent national debate, stimulated partly by the press, involving technology transfer in the Saudi Arabian AWACS sale to observe the current political controversy.

Most research effort has involved methodology and analysis based on individual case study approaches involving technology transfer problems. Only a few attempts have been made to study multiple issues and characteristics of the technology transfer decision process which may be common across diverse national policy sectors (5, p. 5; 9, p. 3-46). A major reason for lack of study on these complex decision processes is the difficulties associated with the high level of abstraction and conceptualization required to define common issues and characteristics among the various technology transfer cases. Abstraction and generalization require simplification. One may argue that current U.S. technology transfer policy is so diffuse and involves such complex issues that decision problems are not easily or quickly resolvable and, therefore, simplistic approaches at generalizing the decision problem may do a great disservice (9, p. 10). However, while these decision processes may indeed be complex, a study of the approach to more abstract, even though simpler processes, may be helpful in understanding the more complex decision problems (10, p. 26).

The purpose here is to present a simple generalized conceptual frame-

work utilizing classical decision theory for analysis of decisions and policy involving technology transfer. Second, the conceptual framework will be related to the nature of technology transfer decision problems. Third, a decision methodology will be formulated to assist in the evaluation of decision alternatives associated with high technology transfer situations. Finally, in Chapter IV several recent technology transfer cases will be reviewed in an attempt to indicate the value of utilization of a common decision methodology across national policy sectors.

CONCEPTUAL FRAMEWORK FOR DECISION ANALYSIS

The decision problem associated with technology transfers can be conceptualized in several ways (11, p. 4; 7, p. 12). A decision is the conclusion of a process which should involve the following elements and steps:

1. recognition that a decision is required
2. determination of goals and objectives (i.e. maximization)
3. enumeration of a limited set of choices or alternatives (A_j) often referred to as strategies
4. definition of events or states of nature (S_i) which effect outcomes associated with the enumerated set of choices or alternatives available
5. measurement of payoffs (P_{ij}) associated with each possible alternative and state of nature
6. determination of conditions under which states of nature occur (i.e. uncertainty, risk, certainty)
7. if risk conditions exist, then evaluation of the relative frequency of occurence of states of nature (risk factors) or subjective judgement (weights) or importance of occurence of each state of nature (R_i). Sum of these risk factors or weights must add to 1.0[1]
8. selection of a decision criteria:
    a. under certainty conditions optimize on known event
    b. under risk conditions utilize maximum expected value criterion

c. under uncertainty conditions decide on one of the criteria below

   1) Wald criterion (maximin/minimax-play safe)
   2) Hurwicz criterion (maximax-optimism)
   3) Savage criterion (minimax-regrets)
   4) La Place criterion (equally likely)

These elements of the decision problem can be presented as components of a decision matrix or tableau (11, p. 4-12). An example of the elementary decision problem is shown in Figure 1.

Risk Assessment Factors (R_i)	Events or States of Nature (S_i)	Alternatives or Choices (A_j) A_1	A_2	A_3	A_4
		Payoffs (P_{ij})			
R_1	S_1	P_{11}	P_{12}	P_{13}	P_{14}
R_2	S_2	P_{21}	P_{22}	P_{23}	P_{24}
R_3	S_3	P_{31}	P_{32}	P_{33}	P_{34}
R_4	S_4	P_{41}	P_{42}	P_{43}	P_{44}
R_5	S_5	P_{51}	P_{52}	P_{53}	P_{54}
$\Sigma R_i = 1.0$					
Decision Criteria Used: Expected Value = EV_j		EV_1	EV_2	EV_3	EV_4

where $EV_j = \Sigma R_i P_{ij}$ $i=1,2,\ldots m$ for each state
$j=1,2,\ldots n$ for each alternative

Figure 1. Decision Matrix

Decision processes vary in degree of complexity from those processes which can be completely specified and have repeated resolutions with similar data producing the same result to those processes which can not be specified in advance, which must be resolved on the basis of experience and judgement, and which may lead rational individuals to reach quite different decisions

with the same information (10, p. 24). Also, conditions under which decisions are made vary from situations where outcomes are known with certainty to other decisions processes which involve risk and uncertainty about future events or outcomes. Additionally, in some decision processes the decision involves data parameters and requirements which are readily understood and easily quantified (i.e. profits, costs, etc.), while in other decision processes it may not be easy to find simple quantitative data to assist in measurement of outcomes.

However, the very nature of the decision problem involves a search for a process which leads to "better" decisions; decisions which yield greater achievement of goals or objectives. A better decision can be defined in terms such as consistency, efficiency, or equity. Better decisions can also be defined in terms of common agreement on conceptualization of the decision problem at the outset. If we can define and agree upon decision alternatives, possible events or states which might occur, the degree of uncertainty associated with the events, and the decision criteria to use, then we at least have some common ground and rational reason for viewing the context of the remainder of the decision problem and the differences which might exist among individuals viewing the same problem.

Conceptualization of decision problems in the above theoretical framework assists in focusing attention upon the essential elements and variables common to all decision problems irrespective of their complexity.

NATURE OF THE TECHNICAL TRANSFER DECISION PROBLEM

Technology transfer policy in the United States has been characterized by a lack of consistent methodology or framework for deciding upon transfer

cases. Additionally there has been lack of agreement on definition of technology transfer and a lack of precise decision criteria to assist in reaching political decisions regarding past technology transfers. Such lack of methodology, definition, and criteria has resulted in U.S. technology transfer policy which is too diffuse and too difficult to implement in a consistent or reliable manner (5, p. 410). Other research also indicates that current decision policy is not consistent from either the view of decision alternatives or objectives of actors formulating policy (5, p. 2). Diffusion of the decision process promulgated by many burearcratic actors suggests that the decision process is characterized by conflict where decision agreement is negotiated (2, p. 12).

Technical transfer assessment is compounded by the conflict of multiple objectives inherent in the definition and pursuit of various national interests (i.e. diplomatic, economic, and security issues). Different personalities responsible for each of the conflicting objectives quite naturally formulate conflicting policy and therefore arrive at different decisions in a specific transfer case. Conflicting objectives requires some ordinal scale of setting priorities or resolving conflict for objective achievement (10, p. 25; 9, p. 24-25).

The conceptual framework presented for analysis of transfer decision indicates assessment of risk or uncertainty as an important element in the decision process. Accurate risk assessment in technology transfer cases requires information that is simply not available in most situations (6, p. 111). However, nonavailability of information does not negate the fact that events remain uncertain and that risk assessment must then be determined on the basis of experience, judgement, or use of some decision

rule (7, p. 5-6).

Outcomes associated with technology transfer policy decisions are not amenable to measurement. Still, policymakers acting rationally must as a minimum ordinally rank the outcomes of a decision alternative with respect to possible events in terms of achievement of prior stated objectives (13, p. 132; 12, p. 48-50; 2, p. 228).

Current high level technology transfer decision processes are often characterized by:

1. many actors. There are at least four major actors: Departments of Commerce, Defense, and State and the National Security Council. Negotiated decisions are the norm.
2. disagreement on objectives. Each actor is influenced by a separate national policy sector and multiplicity of national objectives.
3. inability to define possible future events or states to which are associated outcomes from a particular policy or decision alternative.
4. uniqueness of each transfer case. Due to the uniqueness, little or no information is available to yield risk assessment factors. Lack of information creates substitution of expertise or judgemental factors which can legitimately differ.
5. inability to measure outcomes in a quantifiable manner (i.e. dollars, etc.). Therefore, some ordinal ranking of outcomes based on experience and judgement are utilized.
6. conditions of uncertainty due primarily to uniqueness of the particular transfer case. Uncertainty regarding future events results in disagreement over selection of a decision criteria to use in the decision process.

These characteristics of the technology transfer decision process make generalization or development of general guidelines difficult to formulate. However, we present the hypothesis that adoption of a decision methodology forces actors to focus attention and arguement on the pertinent structural elements of the decision problem (i.e. alternatives, events or states of nature, risk assessment factors, payoffs, and decision criteria). Then,

given agreement on the major structural elements, procedures can be developed which will lead to consistent and rational negotiated policy decisions in a particular technology transfer case.

FORMULATION OF A DECISION METHODOLOGY FOR TECHNOLOGY TRANSFER

The general decision framework presented in Figure 1 can be modified to incorporate technology transfer decision assessment. Assume three major policymakers (actors). These are the Departments of Commerce, Defense, and State. Also, assume for a particular technology transfer case that the three actors have agreed upon four major policy or decision alternatives. The alternatives are 1) grant transfer license without restriction (A_1); 2) control transfer with restrictive licensing (A_2); 3) delay transfer through continued study or development (A_3); 4) do not grant a transfer license (A_4). These alternatives may vary among transfer cases. Further, assume that agreement has been reached among actors on definition of possible events, issues, or impacts which will effect outcome of a particular decision alternative. These issues relate to national policy considerations and are defines as 1) impact upon national security through direct military transfer (S_1); 2) impact upon national security through indirect military transfer (S_2); 3) impact upon economic and foreign trade (S_3); 4) domestic political impact (S_4); and 5) foreign diplomatic and political impact (S_5).

Agreement among actors related to the assumptions stated above may appear monumental. However, acceptance of some theoretical framework for reference by the actors forces attention and agreement on pertinent decision process elements prior to reaching formal decisions.

Given the above assumptions, the policy or decision problem can be formulated as shown in Figure 2. Now that the structure of the technology

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j): Approve Transfer A_1	Restrict Transfer A_2	Delay Transfer A_3	Deny Transfer A_4
		Payoffs (P_{ij})			
R_1	S_1 National Security: Direct Military	P_{11}	P_{12}	P_{13}	P_{14}
R_2	S_2 National Security: Indirect Military	P_{21}	P_{22}	P_{23}	P_{24}
R_3	S_3 Economic/Trade	P_{31}	P_{32}	P_{33}	P_{34}
R_4	S_4 Political: Domestic	P_{41}	P_{42}	P_{43}	P_{44}
R_5	S_5 Political: Foreign	P_{51}	P_{52}	P_{53}	P_{54}
$\Sigma R_i = 1.0$	Decision Criteria: Expected Value = $EV_j = \Sigma R_i P_{ij}$	EV_1	EV_2	EV_3	EV_4

Figure 2.

transfer decision problem is evident we can focus attention on two remaining problems. First, the payoffs (benefits, costs, risks, or utility) must be determined in some quantitative manner. The events or impacts effecting outcomes are not necessarily mutually exclusive. Therefore, variation of one event, economic and trade impacts might have some cross effect on impact of national security through direct military transfers. Each of the events represents a different subset of national goals and objectives. Evaluation of payoffs, if they can be measured, would occur in different types of units. Economics or trade impacts might be measured in tradeoffs of dollar benefits

and dollar costs. Difficulty exists in measurement of variation in the impacts on national security or impacts on political events. Previous research has examined the difficulty in quantifying the payoff matrix (12, p. 49; 2, p. 228-229). One study pertaining directly to technology transfer decision analysis utilized ordinal ranking to evaluate cruciality of policy rationales and decision criteria (1, p. 411-412). In this study the relevant payoffs will be developed using a cardinal scale to evaluate benefits and costs. A scale range from a negative 10 value to a positive 10 value will be utilized. (Any range of cardinal values could be assumed.) For a specific transfer decision case, a list of specific evaluation factors or questions used to determine payoffs will be agreed upon. Such factors or questions might include: 1) provision of new technology; 2) improvement of existing technology; 3) increased manufacturing capability; 4) release of resources; 5) technology available from another foreign source; 6) nature of end user; 7) economic benefits or costs; 8) domestic employment; 9) international diplomacy; and 10) increased prestige and world leadership. These are only examples of a few of the evaluation factors which might be used to quantify payoffs. The procedure would require a policymaker (actor) to vote his preferences, using the prescribed scale, to obtain each of the required payoff values. While this method differs from precise cardinal utility measurement, it nonetheless requires the policymaker to rationally defend the cardinal utility value given each payoff in the decision matrix.

A second problem indicated by the decision framework is the determination of risk assessment factors. In classical decision problems where empirical evidence from previous repetition is available, a probability statement can be generated across mutually exclusive events or states of

nature. A previous author has stated that determination of risk factors requires information that in most cases is simply not available (6, p. 111). Where information is not available to develop associated probabilities or risk factors we must proceed in an environment of uncertainty. Decisions are still required in uncertain environments! So how will the methodology allow a decision? In the case of uncertainty the decision maker must rely on decision criteria or decision rules. (Several classical decision criteria have been mentioned previously on page 18. Other criteria could be developed. Which criteria is utilized is unimportant. The important point is that policymakers (actors) decide on a decision criteria and consistently utilize the selected criteria in formulating policy decisions. Another method which can be used to determine risk factors is the assignment of subjective probabilities or weights to the set of events (2, p. 221; 7, p. 52-54; 11, p. 9). This method requires use of experience and judgement in the assignment of relative weights to the importance of each event. Each policymaker (actor) could assign a set of subjective weights to the events. Admittedly, the weights will be biased in favor of the events most desirable to the policymaker. But, again the policymaker will have to defend the rationale of the weights assigned to each event or impact.

With specification of the decision methodology as formulated above and utilization of a decision criteria, such as maximum expected value, one of the decision alternatives will be indicated as the most appropriate among those alternatives defined. While the methodology presented is by no means complete or perfect, it at least presents a common theoretical framework in which analysis and negotiated agreement can be reached among the actors pertaining to important structural elements in the technology transfer

decision process. It must be understood that there are both advantages and disadvantages associated with the use of this type of methodology for decision making (2, p. 248). But review of current literature related to technology transfer decision processes is nearly void of any hypothesis or proposals pertinent to development of high technology decision methodology.

In the next chapter the case study approach will be utilized to demonstrate use of the proposed methodology to assist in evaluating high technology transfer decision alternatives.

CHAPTER IV

TECHNOLOGY TRANSFER DECISION ANALYSIS

CASE DESCRIPTIONS

Four cases were selected for analysis based on availability of data, relevance to the technology transfer issue, and the broad range of differences in the technology that were transferred. These cases generated controversy at the highest levels of government, received expanded press coverage, and involved the four main technology functions of national security, foreign policy, economics, and scientific exchange.

Each case will be developed through a comparative methodology that investigates the alternatives, factors, and issues confronting any technology transfer question. The decision methodology described in Chapter III is the foundation of the analysis and should demonstrate the capability of evaluating decision alternatives associated with technology transfer cases.

These cases are as follows:

1. General Electric -- SNECMA Jet Engine Development Program (CFM-56)
2. Cyril Bath Company -- Stretch Forming Press
3. Dresser Industries -- Oil Drillbit
4. Kama River Truck Plant

GE-SNECMA Jet Engine Development Case

Background. The GE-SNECMA case surfaced in mid-1972 based on a proposed joint venture between General Electric Corporation and the French national engine firm, SNECMA (8, p. 1-12). Both firms felt unable to pursue new engine development independently due to cost and risk involved in

such a venture. The problem dealt with the level of technology in the CMF-56 engine, since it was built on the B-1 engine design and could not be transferred under the Munition Control Act that limited aircraft engine export to older technology. Further, Pratt and Whitney, the United States Air Force and the U.S. Department of Defense opposed the sale, while the President of France and the President of the United States favored the transfer. It was the view of the Defense Department that the main objective of export controls is "to protect the United States" lead time relative to its adversaries in the application of technology to military capabilities. The level of know-how embodied in the engine for the B-1 posed a national security problem if the technology was transferred (3, p. 53). The compressor and turbine sections contained design features that Defense considered sensitive. The technique used to cool the hot suction turbine, the design of the high pressure compressor, and the engine thermodynamics were crucial to the performance of military jets. If transferred, the CFM-56 technology would compromise the United States aircraft industry lead in turbine engine technology. Defense believed that reverse-engineering of the hardware would provide the know-how for design and manufacture by enhancing Soviet technology beyond their present capability and years ahead of their current expectations (8, p. 10).

Evaluation Factors.

1. Improve existing technology: Engine improvements in the compressor and turbine section contained technology that increased thrust while reducing the fuel requirement. Also improvements in thermodynamics were designed into the engine which is crucial to military jet performance.

2. Manufacturing capability: Originally the French SNECMA company as a partner would develop and manufacture the CFM-56 engine in France. A

later proposal limited development to the United States and transfer of manufacturing capability approval later.

3. Revolutionary change: The degree of change is significant both in the technology and in the request to have joint development and manufacture. The risk involved was such that both GE and SNECMA felt they could not accomplish the task alone.

4. Reverse engineering: Since this technology is an improvement to existing technology, concern for the release of the know-how in the technology was dominant. The Defense Department felt strongly about this aspect of the agreement which caused the agreement to be changed and the development to remain in the United States.

5. Economic cost benefits: Commercial sales were part of the incentive for the joint venture. Research and development recoupment was estimated to be $80 million with possible tariff benefits within the European Common Market.

6. International diplomacy: The Department of State endorsed the venture as, "in the national interest." The technology was promised during the Nixon-Pompidou Summit in the Azores. Without approval the Administration could experience embarrassment internationally.

Cyril Bath Company -- Stretch-Forming Press Case

Background. The Cyril Bath Company received inquiry from a Soviet automobile foreign trade organization on the purchase of stretch-forming hydraulic presses used to press large metal sheets. These type of stretch-forming presses can be used in the aircraft and automotive industry. What created the controversy was the fact that the Cyril Bath stretch-forming

presses were used primarily in the aircraft industry and the Soviets proposed to use them, with a loss of efficiency, in their automotive industry. Additionally, the request followed a prior sell by the French, which was in violation of the COCOM list (1, p. 417).

The Cyril Bath request for export license was denied as a violation of national security based on the direct contribution of the machinery to the construction of Soviet aircraft. This denial was vigorously contested by Cyril Bath based on the availability from foreign sources, low level of sophistication and that the contract meant a large increase in employment. Based on this appeal, the license was subsequently approved (6, p. 6-15).

Evaluation Factors.

1. Foreign available: French companies provided seven stretch-forming presses to the Soviets prior to the license request by Cyril Bath.

2. Manufacturing capability: The licensing request was to provide the equipment with dies, tooling, and numerical control apparatus which would enable expanded manufacture capability.

3. Nature of end-use: Since the Cyril Bath Company press is more efficient in aircraft production, the ultimate end use of the equipment was seriously questioned.

4. Economic cost benefits: Employment in the Cleveland area would be improved with the Cyril Bath Company employment potential increasing 50%. The contract provided a $1.3 million near term gain with possible future sales.

5. International diplomacy: Machines such as the stretch-forming press are contained on the COCOM export list. Although of some concern, the French had already provided similar equipment without COCOM approval.

Kama River Truck Plant Case

Background. Although the Kama River Truck Plant held no strategic military advantage, the transfer occurred from the equipment provided and related technology inherent in a turn-key operation. Due to the complexity of the plant, six companies provided foundry process, engine assembly line, and computers for automating the assembly line. The Soviets received technology transfer of assembly line technology and computer control capabilities which all have military application (4, p. 54). In the case of the trucks manufactured, they were first noticed in military use by Soviet forces in East Germany in 1977. More recently, they were used by the military in the invasion of Afganistan in 1979 (5, p. 27).

Dr. Fedoseyev stated it clearly: "It should be considered that there is practically no strictly and purely civilian industry in the U.S.S.R. The entire country in one manner or another serves the military establishment and purpose" (2, p. 25-31).

Evaluation Factors.

1. Improve existing technology: The Soviet assembly line technology was limited to manual operation prior to the introduction of the automated assembly line technology. How far the assembly line technology is transferable to other industries is speculation, but the truck output will be 150,000 per year with an additional 100,000 engines (7, p. 10).

2. Provide manufacturing capability: Although the manufacturing capability for trucks was available prior to the Kama River Plant, the increase in capability is staggering. The assembly line was automated and the load capability of the truck increased 60%.

3. Release resources: The increased load capability releases other

load capabilities and as the truck is put to military uses the logistics support is significantly increased and improved.

4. *Nature of end-use:* The original technology transfer was to have provided civilian trucks, but as noted more and more are appearing in military units and for military support.

5. Economic cost benefit: The contract for the complete turn-key operation exceeds $1 billion. Although the total truck plant was contracted to firms from five nations, the cost benefits and employment potentials were considerable.

Dresser Industries Export Licensing Case

Background. The Stankomport Soviet trade organization arranged for the Dresser Industries to provide a drill bit plant that would improve rock drill bit production capability and increase bit durability. The technology to be transferred would be tungsten-carbide quality and the electron beam welder. A further question surfaced as to the United States' interest in improving Soviet energy production and military application. The energy question was an obvious improvement, but the greater concern involved the possibility of diverting the technology into tungsten-carbide penetrators for armor. President Carter, based on the Dresser case, placed all exports of oil equipment and technology to the Soviets under mandatory licensing review. Due to the significant size of the trade with the Soviets, the Dresser executives sought to publicize the loss of employment and revenue potential (2, p. 33-45). Also Dresser alleged that other Western nations could provide the same technology if the United States refused. The request was approved in 1979, but subsequently withdrawn as President Carter

departed the Office of President (1, p. 415).

Evaluation Factors.

1. Improved existing technology: A marked change in drill bit production of 10% and a 500% improvement in quality would transpire if the plant were built. This is even more significant considering that the Soviet's existing drill bit production capability is one of the largest in the world.

2. Manufacturing capability: Although the Soviets possess a manufacturing capability, the proposed plant by Dresser would provide the tungsten-carbide technology along with an improved production capability using the electronic beam welder.

3. Revolutionary change: This improvement consists of the tungsten-carbide process, which could be used by the Soviets to improve ammunition, thereby representing a gigantic leap ahead for the Soviets. Additionally, the electronic beam welder provided a technology easily transferable to other industries (1, p. 4-16).

4. Foreign availability: Other Western nations are capable of providing the advanced drill bit production to include the electronic beam welder. Considering the potential employment and large revenue expected from this sale, foreign availability played a large role in the controversy.

5. Economic cost benefits: The Dresser press agreement balanced financial profits with the possible military advantage provided to the Soviets. The financial profits were estimated at $10 billion over a five year period.

6. Domestic employment: Estimation of potential employment was in the half-million range. This estimation brought extreme political interest

suggesting a hands-off attitude because the financial and employment benefits were substantial.

7. Prestige and world leadership: Considering the size and importance of the contract to the Soviets, the approval was held as a signal of U.S. dissatisfaction with the issue of human rights policies within the Communist camp.

ANALYSIS

Demonstration of the methodology presented in Chapter III utilizes the following simulation procedure. Each co-author of this study was selected to represent one of the three principal actors or policymakers (Departments of Commerce, Defense, and State) in the technology transfer decision process. For each of the four technology transfer cases reviewed above the actor was given a blank decision matrix tableau similar to the tableau depicted in Figure 2. After review of a particular case including pertinent evaluation factors impacting upon the decision, the actor was instructed to prepare or vote payoffs utilizing a scale of minus 10 to plus 10. Negative values indicate net negative assessment or impact upon national interests, while positive values indicate an assessment in which benefits of the particular alternative exceed "costs" for the indicated event. After determination of payoffs were completed, each actor was required to assign risk factors or weights to the potential events or impacts.

Given the actors; set of risk factors and the payoffs, a weighted index comparable to the expected value decision criterion was calculated and used to arrive at a quantitative index or value for each decision alternative in each case. These values measure tradeoff of net benefits

and costs associated with each decision alternative in each case. The optimal decision for a specific actor and case is indicated by the maximum index of value associated with the stated alternatives. The results of this analysis are shown at Appendix 3.

High technology transfer decision policy indicated by this simulated procedure is presented along with a comparison to the actual administrative or political decisions implemented by policymakers for each of four transfer cases in Figure 3.

In the General Electric case, the simulation analysis indicated restricted transfer by both the Department of Commerce and the Department of State, while the Department of Defense supported a denial of the transfer. The two actual Presidential decision reviews of this case were first to deny transfer; but, then, a second subsequent decision was made to restrict transfer. Note the simulated decisions by the actors which incorporated the postulated methodology did not vary from those alternatives actually chosen by Presidential review.

For Case 1, a simulated decision incorporating all three actors' viewpoints was attempted. All actors' decision tableaus were given equal weight through a simple averaging process, although differing weights could have been used given some justification. The resultant decision tableau appears in Appendix 3. This procedure might represent the concensus of a negotiated decision process among the actors or a decision representative of higher political authority or review utilizing input from the major actors (i.e. Commerce, Defense, and State). For example, this resultant tableau might represent a decision recommendation by the National Security Council to the President. In this particular case, the simulated negotiated decision

Case	Decision Alternatives			
	A_1	A_2	A_3	A_4
	Approve Transfer	Restrict Transfer	Delay Transfer	Deny Transfer
<u>Case 1. General Electric</u>				
Simulated Decision				
Commerce		X		
Defense				X
State		X		
"Negotiated"				X
Actual Decision				
1st Review (Presidential)				X
2nd Review (Presidential)		X		
<u>Case 2. Cyril Bath</u>				
Simulated Decision				
Commerce				X
Defense				X
State	X			
Actual Decision				
1st Review				X
2nd Review (Presidential)	X			
<u>Case 3. Kama River</u>				
Simulated Decision				
Commerce			X	
Defense				X
State	X			
Actual Decision				
Review	X			
<u>Case 4. Dresser Industries</u>				
Simulated Decision				
Commerce	X			
Defense				X
State	X			
Actual Decision				
1st Review (Presidential)	X			
Approval Withdrawn (Presidential)				X

Figure 3. Comparison of Simulated Decisions with Actual Decisions

indicated a denial of transfer which agreed with the actual first Presidential decision.

In the Cyril Bath case the simulated decision indicated denial of transfer by Commerce and Defense and approval of transfer by State. Two actual decision reviews were accomplished. A first decision was made to deny transfer. A later Presidential review of the case subsequently approved the transfer. Both actual decisions were supported by one or more of the actors utilizing the simulated decision methodology.

Similar results are indicated by both the Kama River and the Dresser Industries high technology transfer cases. In all cases presented actual decisions concurred with an alternative selected by at least one of the actors in the simulated decision environment. While statistical significance can not be implied, it is interesting to note that in each of the cases reviewed utilization of the simulated methodology by the actors did not select a decision alternative that was later selected in the actual decision process.

CHAPTER V

CONCLUSIONS

Current high technology transfer control and decision processes are complicated and diffused both in terms of the conflicting goals of actors formulating critical policy and in terms of rational consistent process or methodology used to form technology transfer decisions.

It has been suggested by previous research that the decision and policy process should be more centralized and that analysis should be generalized and based upon quantifiable tradeoffs among benefits, costs, and risk associated with achievement of multiple and often conflicting national interests.

This study presents only a conceptual approach or methodology for consistently evaluating decision alternatives associated with high technology transfer. Poor definition, uniqueness of each technology transfer situation, and lack of information do not allow presentation of a formal mathematical decision model. Nor was that the objective of this study. However, the approach presented does force a consistent focus of attention upon critical elements of the decision problem which require better definition. The approach also indicates those elements of the decision problem that may be generalized or common to many technology transfer decision situations. Finally, the methodology indicates specifically the areas where data and information are required if consistent, rational decisions are to be made with respect to high technology transfer policy.

This methodology is not a panacea. Other methods exist in the literature (use of decision trees, mathematical programming, etc.) which

could lend additional insight to evaluating the decision processes involved in technology transfer. The major objective of this study has been to demonstrate how the actors in the technology transfer decision process might focus their attention consistently on the critical elements of the decision problem. If the actors are "tuned" to a common decision approach or methodology at the executive level, then decision agreement may be facilitated by negotiating specific and legitimate differences of interests, definition, and data measurement.

APPENDIX 1

FOOTNOTES & REFERENCES

CHAPTER I

1. Bricker, Rodney P.G., U.S. Technology Transfer To The Soviet Union, Air War College, 1981.

2. Bucy, J. Fred, "On Strategic Technology Transfer To The Soviet Union," International Security, Spring, 1977.

3. National Science Foundation, Technology Transfer and Utilization, Report #10, Washington, D.C., 1974.

4. Nau, Henry R., Technology Transfer and U.S. Foreign Policy. New York: Praeger Publisher, 1976.

5. U.S. Congress, Office of Technology Assessment. Technology and East West Trade. Washington, D.C.: Office of Technology Assessment, Nov. 1979.

6. U.S. Congress. Senate. Committee on Government Affairs. Senator Garn Speaking on an Office of Strategic Trade, 30 Sept 1980, 96th Cong., 2d. sess., Washington, Congressional Record, Vol. 126, S14176-S 14177.

7. U.S. Congress. House. Committee on Foreign Affairs. Technology Export. 96th Cong., 1st sess., Washington: Government Printing Office, 30 Oct 1979.

8. U.S. Congress. House. Joint Economic Committe, Issues in East-West Commercial Relations, A Compendium of Papers Submitted to the Joint Economic Committee. Joint Committee Print, 95th Cong., 2d sess., 1979.

9. Weinberger, Casper W., "Technology Transfers to The Soviet Union," The Wall Street Journal, 12 Jan 1982.

10. Zaleski, Eugene and Helgard Wienert. Technology Transfer Between East & West. Paris: OECD Publications, 1980.

CHAPTER II

1. American Enterprise Institute. Legislative Analyses, Controls for Advanced Technology. Washington, D.C.: American Enterprise Institute for Public Policy Research, 1979.

2. Bertsch, Gary K., Richard T. Cupitt, John R. McIntyre and Brian K. Robinson, "Decision Dynamics of Technology Transfer to the U.S.S.R.," Technology in Society, An International Journal, Vol 3, No. 4, 1981.

3. Bucy, J. Fred, Statement to the 10th International Management Symposium, East West Technology Transfer and Security of the Western World. Saint Gall Graduate School (HSG), May 11-14, 1980.

4. Bucy, J. Fred, "On Strategic Technology Transfer to the Soviet Union," International Security, Spring, 1977.

5. Bricker, Rodney P.G., U.S. Technology Transfer to the Soviet Union: A Dilemma, Air War College, 1981.

6. Gee, Sherman, Technology Transfer, Innovation, and International Competitiveness, New York: John Wiley and Son, 1981.

7. Hough, W. Granville, Technology Diffusion. Mt. Airy, Maryland: Lomand Books, 1975.

8. Nau, Henry R., Technology Transfer and U.S. Foreign Policy. New York: Praeger Publisher, 1976.

9. Nimitz, A.E. and Turn, R., Computers and Strategic Advantage: 1 Computer Technology in the United States and the Soviet Union, Santa Monica, Ca: Rand Corp., 1960.

10. Perlmutter, Howard V. and Tagi Sagafi-nejad, International Technology Transfer, New York: Pergamon Press, 1981.

11. U.S. Congress. House. International Transfer of Technology. Report to the President of th Congress, Subcommittee on International Security and Scientific Affairs, 95th Cong., 2d sess., 1978.

12. U.S. Congress. House. Joint Economic Committee. Issues in East-West Commercial Relations, A Compendium of Papers Submitted to the Joint Economic Committee. Joint Committee Print, 95th Cong., 2d sess., 1979.

13. U.S. Congress, Office of Technology Assessment. Technology and East West Trade, Washington, D.C.: Office of Technology Assessment, 1979.

14. Vorona, Jack. The Soviet March Toward Technology Superiority. Defense 80, U.S. Government Printing Office, Washington, D.C., 1980.

CHAPTER III

1. Bertsch, Gary K., Richard T. Cupitt, John R. McIntyre and Brian K. Robinson, "Decision Dynamics of Technology Transfer to the U.S.S.R.," Technology in Society, An International Journal, Vol 3, No. 4, 1981.

2. Harrison, E. Frank, The Managerial Decision-Making Process, Boston: Houghton Mifflin, 1975.

3. Holliday, George D., Technology Transfer to The U.S.S.R., 1928-1937 and 1966-1975: The Role of Western Technology in Soviet Economic Development, Boulder, Co: Westview Press, 1979.

4. Kuehn, Thomas J. and Alan L. Porter, eds., Science, Technology, and National Policy, Ithaca, NY: Cornell University Press, 1981.

5. Nau, Henry R., Technology Transfer and U.S. Foreign Policy, New York: Praeger Publisher, 1976.

6. Nelkin, Dorothy, ed., Controversy-Politics of Technical Decisions, London: Sage Publications, 1979.

7. Newman, Joseph W., Management Applications of Decision Theory, New York: Harper and Row, Publishers, 1971.

8. Norris, William C., A Policy for Export of Products of Technology: Series of Perspectives on Employing Technology to Solve the Pressing Problems of Society, Control Data Corporation, September, 1977.

9. Perlmutter, Howard V. and Tagi Sagafi-nejad, International Technology Transfer, New York: Pergamon Press, 1981.

10. Radford, K. J., Managerial Decision Making, Reston, VA: Reston Publishing Company, 1975.

11. Rappaport, Alfred, ed., Information for Decision Making, New Jersey: Prentice Hall, 1970.

12. Shubik, Martin, Readings in Game Theory and Political Behavior, New York: Double Day and Company, 1954.

13. Spencer, Daniel L. and Alexander Woroniak, eds., The Transfer of Technology to Developing Countries, New York: Praeger Publishers, 1967.

14. U.S. Congress, Office of Technology Assessment, Technology and East West Trade, Washington, D.C.: Office of Technology Assessment, Nov., 1979.

15. Zaleski, Eugene and Helgard Wienert, Technology Transfer Between East and West, Paris: OECD Publications, 1980.

CHAPTER IV

1. Bertsch, Gary K., Richart T. Cupitt, John R. McIntyre and Brian K. Robinson, "Decision Dynamics of Technology Transfer to the U.S.S.R.,"

Technology in Society, An International Journal, Vol 3, No. 4, 1981.

2. Bricker, Rodney P.G., U.S. Technology Transfer to the Soviet Union: A Dilemma, Air War College, Research Report No. MS094-81, 1981.

3. Gee, Sherman, Technology Transfer, Innovation, and International Competitiveness, New York: John Wiley and Son, 1981.

4. Holliday, George D., Technology Transfer to The U.S.S.R., 1928-1937 and 1966-1975: The Role of Western Technology in Soviet Economic Development, Boulder, Co: Westview Press, 1979.

5. "U.S. Still Selling Technology to Russia," To The Point, 8 August 1980.

6. U.S. Congress. House. Subcommittee on International Economic Policy and Trade, Export Licensing. Foreign Availability of Stretch Forming Presses. 95th Cong., 1st sess., Washington: Government Printing Office, 1977.

7. Vorona, Jack, "The Soviet March Toward Technology Superiority," Defense 80, Washington: Government Printing Office, 1980.

8. Weiss, Gus W. Jr., Interview and Paper Provided, "The CMR-56--The General Electric-SNECMA Jet Engine Development Program," Washington, D.C., 1980.

APPENDIX 2

BIBLIOGRAPHY

Allen, Thomas J., Managing the Flow of Technology, Cambridge, Mass: The MIT Press, 1978.

Amann, R., J. M. Cooper, and R. W. Davis, eds., The Technological Level of Soviet Industry, New Haven, Conn: Yale University Press, 1977.

American Enterprise Institute, Legislative Analyses Controls for Advanced Technology, Washington, D.C.: American Enterprise Institute for Public Policy Research, 1979.

Basiuk, Victor, Technology, World Politics, and American Policy, New York: Columbia University Press, 1977.

Bertsch, Gary K., Richard T. Cupitt, John R. McIntyre and Brian K. Robinson, "Decision Dynamics of Technology Transfer to the U.S.S.R.," Technology in Society, An International Journal, Vol 3, No. 4, 1981.

Bricker, Rodney P.G., U.S. Technology Transfer to the Soviet Union: A Dilemma, Air War College, Research Report No. MS094-81, 1981.

Bucy, J. Fred, "On Strategic Technology Transfer to the Soviet Union," International Security, Spring, 1977.

Bucy, J. Fred, Statement to the 10th International Management Symposium, East West Technology Transfer and Security of the Western World, Saint Gall Graduate School (HSG), May 11-14, 1980.

Clabaugh, Samuel F. and Richard V. Allen, East West Trade, Its Strategic Implications Analysis and Inventory of Congressional Documents 1956-1963, Washington, D.C.: Center for Strategic Studies, R-2-64.

Doctors, Samuel I., The Role of Federal Agencies in Technology Transfer, Cambridge, Mass: The MIT Press, 1969.

Gee, Sherman, Technology Transfer, Innovation, and International Competitiveness, New York: John Wiley and Son, 1981.

Glenn, Maxwell, "Exporting Technology--Can Trade and National Security Coexist," National Journal, No 33, Aug 18, 1979.

Harrison, Frank E., The Managerial Decision-Making Process, Boston: Houghton Mifflin Co., 1975.

Holliday, George D., Technology Transfer to The U.S.S.R., 1928-1937 and 1966-1975: The Role of Western Technology in Soviet Economic Development,

Boulder, Co: Westview Press, 1979.

Hough, W. Granville, Technology Diffusion, Mt. Airy, Maryland: Lomond Books, 1975.

Kililgaard, Robert E., National Security and Export Controls, Santa Monica, Ca: Rand Corp., 1974.

Kleiman, Herbert S., Final Summary Report on Identification of Strategically Significant Technologies, DOD Sponsored, Battelle Memorial Institute, Columbus, Ohio, Jan. 1978.

Kuehn, Thomas J. and Alan L. Porter, eds., Science Technology and National Policy, New York: Cornell University Press, 1981.

National Aeronautics and Space Administration, Assessing Technology Transfer, (by Richard L. Lesher and George J. Howick), Washington, D.C.: U.S. Government Printing Office, 1966.

Nau, Henry R., Technology Transfer and U.S. Foreign Policy, New York: Praeger Publisher, 1976.

Nelkin, Dorothy, ed., Controversy--Politics of Technical Decisions, London: Sage Publications, 1979.

Newman, Joseph W., Management Applications of Decision Theory, New York: Harper and Row, 1971.

Nimitz, A.E. and Turn, R., Computers and Strategic Advantage: 1 Computer Technology in the United States and the Soviet Union, Santa Monica, Ca: Rand Corp., 1960.

Perlmutter, Howard V. and Tagi Sagafi-nejad, International Technology Transfer--Guidelines, Codes and a Muffled Quadrilogue, New York: Pergamon Press, 1981.

Possony, Stefan and J.E. Pournelle, The Strategy of Technology, Winning the Decisive War, Cambridge, Mass: Dunellen, 1970.

Radford, K.J., Managerial Decision Making, Reston, Va: Reston Publishing Co., 1975.

Ramo, Simon, America's Technology Slip, New York: John Wiley and Son, 1980.

Rappaport, Alfred, ed., Information for Decision Making, New Jersey: Prentice Hall, Inc., 1970.

Shubik, Martin, Reading in Game Theory and Political Behavior, New York: Doubleday and Company, Inc., 1954.

Spencer, Daniel L. and Alexander Woroniak, eds., The Transfer of Technology

to Developing Countries, New York: Praeger, 1967.

Turn, R., M.R. Davis, E.W. Paxon, and R.E. Strauch, Computers and Strategic Advantage: 11 Capability-Enhancing Applications, Santa Monica, Ca: Rand Corp., 1975.

U.S. Congress. House. Committee on Foreign Affairs, Technology Exports, Department of Defense Organization and Performance, Hearing, 96th Cong., 1st sess., Oct 30, 1979, Washington: Government Printing Office, 1980.

U.S. Congress. House. Committee on Foreign Affairs, Technology Export, 96th Cong., 1st sess., Washington: Government Printing Office, Oct 30, 1979.

U.S. Congress. House. International Transfer of Technology, Report to the President of the Congress, Subcommittee on International Security and Scientific Affairs, 95th Cong., 2nd sess., 1978.

U.S. Congress. House. Joint Economic Committee, Issues in East-West Commercial Relations, A Compendium of Papers Submitted to the Joint Economic Committee, Joint Committee Print, 95th Cong., 2nd sess., 1979.

U.S. Congress. House. Subcommittee on International Economic Policy and Trade, Export Licensing, Foreign Availability of Stretch Forming Presses, 95th Cong., 1st sess., Washington: Government Printing Office, 1977.

U.S. Congress. Senate. Committee on Government Affairs, Senator Garn Speaking on an Office of Strategic Trade, Sept 30, 1980, 96th Cong., 2nd sess., Washington: Congressional Record, Vol. 126, S14176-S 14177.

U.S. Congress, Office of Technology Assessment, Technology and East West Trade, Washington, D.C.: Office of Technology Assessment, Nov., 1979.

U.S. Congress. Senate. Subcommittee on International Finance of Committee on Banking, Housing and Urban Affairs, East West Trade and U.S. Markets Shares, 96th Cong., 1st sess., Washington: Government Printing Office, 1980.

U.S. Department of Commerce, Quantification of Western Exports of High Technology Products to Communist Countries, Project D-41 (by John A. Martens) Washington: Jan., 1981.

U.S. Department of State, Impact on U.S. Commercial Interest of Technology Transfer to the U.S.S.R., Office of External Research, INR/XRS-3, Washington: Aug., 1976.

"U.S. Still Selling Technology To Russia," To The Point, Aug 8, 1980.

vonNeuman, J. and O. Mogenstern, Theory of Games and Economic Behavior, Princeton, New Jersey: Princeton University Press, 1953.

Norris, William C., "A Policy for Export of Products and Technology," Control Data Corporation: Series of Prospectives on Employing Technology

to Solve the Pressing Problems of Society, No 3, Sept, 1977.

Vorona, Jack, "The Soviet March Toward Technology Superiority," Defense 80, Washington: Government Printing Office, 1980.

Weinberger, Casper W., "Technology Transfer to The Soviet Union," The Wall Street Journal, Jan 12, 1982.

Weiss, Gus W. Jr., Interview and Paper Provided, "The CMR-56--The General Electric-Electric-SNECMA Jet Engine Development Program," Washington, D.C., 1980.

Zaleski, Eugene and Helgard Wienert, Technology Transfer Between East and West, Paris: OECD Publications, 1980.

APPENDIX 3

DECISION ANALYSIS WORKSHEETS

Each co-author of this study representing a principal actor or policy-maker reviewed the cases selected for analysis. After review, each actor was provided a blank decision matrix tableau. The actors were instructed to prepare or vote payoffs utilizing the scale of minus 10 to plus 10. Negative values indicated net negative assessment or impact upon national interests, while positive values indicated an assessment in which benefits of the particular alternative exceed "costs" for the indicated event. After determination of payoffs were completed, each actor was required to assign risk factors or weights to the potential events or impacts. A detailed discussion of the analysis is contained in Chapter IV.

The results of the voting for each case study follow.

HIGH TECHNOLOGY TRANSFER CASE: General Electric

ACTOR: Negotiated among all

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j)			
		A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .3	S_1 National Security: Direct Military	-6.7	-1.3	+1.3	+8.3
R_2 .167	S_2 National Security: Indirect Military	-3.0	+1.7	+2.7	+3.7
R_3 .233	S_3 Economic/Trade	+6.3	+3.7	-1.0	-6.7
R_4 .1	S_4 Political: Domestic	-.7	+1.0	+1.3	+3.0
R_5 .2	S_5 Political: Foreign	+4.7	+1.7	-2.0	-1.3
$\Sigma R_i = 1$	Decision Criteria: Expected Value	-2.5	1.2	.3	+1.6

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Revolutionary change
4. Reverse engineering
5. Economic cost and benefits
6. International diplomacy

HIGH TECHNOLOGY TRANSFER CASE: General Electric

ACTOR: Commerce

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j): A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .3	S_1 National Security: Direct Military	-6	-2	+2	+7
R_2 .2	S_2 National Security: Indirect Military	-2	0	+1	+3
R_3 .3	S_3 Economic/Trade	+7	+4	-2	-8
R_4 .1	S_4 Political: Domestic	+5	+3	+1	-2
R_5 .1	S_5 Political: Foreign	+3	+2	0	-2
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+.7	+1.1	+.3	-.1

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Revolutionary change
4. Reverse engineering
5. Economic cost and benefits
6. International diplomacy

HIGH TECHNOLOGY TRANSFER CASE: General Electric

ACTOR: Defense

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .4	S_1 National Security: Direct Military	-9	-5	-4	+10
R_2 .2	S_2 National Security: Indirect Military	-7	+5	+7	+8
R_3 .1	S_3 Economic/Trade	+4	+2	+1	-2
R_4 .1	S_4 Political: Domestic	-5	0	0	+6
R_5 .2	S_5 Political: Foreign	+3	-2	-1	+4
$\Sigma R_i = 1$	Decision Criteria: Expected Value	-4.5	-1.2	-.3	+6.8

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Reverse engineering
4. Economic cost and benefits
5. International diplomancy

HIGH TECHNOLOGY TRANSFER CASE: General Electric

ACTOR: State

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j): A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .2	S_1 National Security: Direct Military	-5	+3	+6	+8
R_2 .1	S_2 National Security: Indirect Military	0	0	0	0
R_3 .3	S_3 Economic/Trade	+8	+5	-2	-10
R_4 .1	S_4 Political: Domestic	-2	0	+3	+5
R_5 .3	S_5 Political: Foreign	+7	+5	-5	-6
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+3.3	+3.6	-.6	-2.7

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Revolutionary change
4. Reverse engineering
5. Economic cost and benefit
6. International diplomacy

HIGH TECHNOLOGY TRANSFER CASE: Cyril Bath

ACTOR: Commerce

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j): A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .2	S_1 National Security: Direct Military	-5	-3	0	+4
R_2 .3	S_2 National Security: Indirect Military	-3	-3	-1	+1
R_3 .2	S_3 Economic/Trade	+4	+2	+1	-2
R_4 .2	S_4 Political: Domestic	+2	+1	-1	-2
R_5 .1	S_5 Political: Foreign	+1	+1	0	-1
$\Sigma R_i = 1$	Decision Criteria: Expected Value	-.6	-.8	-.3	.2

Evaluation Factors:

1. Foreign availability
2. Manufacturing capability
3. Nature of end-use
4. Economic cost and benefits
5. International deplomacy

HIGH TECHNOLOGY TRANSFER CASE: Cyril Bath

ACTOR: Defense

Risk Factors (R_i)	Events or Impacts (S_i)	A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Alternatives or Choices (A_j)			
		Payoffs (P_{ij})			
R_1 .3	S_1 National Security: Direct Military	-7	+5	+6	+8
R_2 .2	S_2 National Security: Indirect Military	-5	0	0	+7
R_3 .2	S_3 Economic/Trade	+5	+3	+2	+8
R_4 .1	S_4 Political: Domestic	+2	0	0	-7
R_5 .2	S_5 Political: Foreign	+2	0	0	-7
$\Sigma R_i = 1$	Decision Criteria: Expected Value	-1.5	+2.1	+2.2	+3.3

Evaluation Factors:

1. Foreign Availability
2. Manufacturing capability
3. Nature of end-use
4. Economic cost and benefit
5. International diplomacy

HIGH TECHNOLOGY TRANSFER CASE: Cyril Bath

ACTOR: State

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .1	S_1 National Security: Direct Military	-6	-3	+4	+6
R_2 .2	S_2 National Security: Indirect Military	-9	-5	+7	+9
R_3 .4	S_3 Economic/Trade	+9	+5	-3	-8
R_4 .1	S_4 Political: Domestic	-2	+1	+3	+4
R_5 .2	S_5 Political: Foreign	+3	+1	-2	-5
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+1.6	+1.0	+.5	+1.4

Evaluation Factors:

1. Foreign Availability
2. Manufacturing capability
3. Nature of end-use
4. Economic cost and benefit
5. International diplomacy

HIGH TECHNOLOGY TRANSFER CASE: Kama River Truck Plant

ACTOR: Commerce

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .2	S_1 National Security: Direct Military	-3	-2	0	+2
R_2 .3	S_2 National Security: Indirect Military	-4	-1	+1	+3
R_3 .3	S_3 Economic/Trade	+5	+2	0	-4
R_4 .1	S_4 Political: Domestic	+2	+1	0	-1
R_5 .1	S_5 Political: Foreign	+2	+1	+1	-1
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+.1	+.1	+.4	-.1

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Release resource
4. Nature of end-use
5. Economic cost and benefit

HIGH TECHNOLOGY TRANSFER CASE: Kama River Truck Plant

ACTOR: Defense

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .4	S_1 National Security: Direct Military	-7	-5	-4	+8
R_2 .3	S_2 National Security: Indirect Military	-5	-3	-2	+8
R_3 .1	S_3 Economic/Trade	+4	+3	+2	-5
R_4 .1	S_4 Political: Domestic	+3	0	0	-5
R_5 .1	S_5 Political: Foreign	+4	0	0	-1
$\Sigma R_i = 1$	Decision Criteria: Expected Value	-3.2	-2.6	-2.0	+4.5

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Release resource
4. Nature of end-use
5. Economic cost and benefit

HIGH TECHNOLOGY TRANSFER CASE: Kama River Truck Plant

ACTOR: State

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .1	S_1 National Security: Direct Military	-.3	-.2	0	+.5
R_2 .3	S_2 National Security: Indirect Military	-7	-5	+2	+7
R_3 .4	S_3 Economic/Trade	+8	+5	-3	-8
R_4 .1	S_4 Political: Domestic	+.5	+.3	-.5	-.6
R_5 .1	S_5 Political: Foreign	+.5	0	-.3	-.4
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+1.8	+.6	-1.4	-1.6

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Release resources
4. Nature of end-use
5. Economic cost and benefit

HIGH TECHNOLOGY TRANSFER CASE: Dresser Industries

ACTOR: Commerce

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .2	S_1 National Security: Direct Military	-5	-2	0	+6
R_2 .2	S_2 National Security: Indirect Military	-2	0	+1	+2
R_3 .3	S_3 Economic/Trade	+7	+3	+1	-5
R_4 .2	S_4 Political: Domestic	+3	+2	0	-2
R_5 .1	S_5 Political: Foreign	+1	+1	0	-1
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+1.4	+1.0	+.5	-.4

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Revolutionary change
4. Foreign availability
5. Economic cost and benefit
6. Domestic employment
7. Prestige and world leadership

HIGH TECHNOLOGY TRANSFER CASE: Dresser Industries

ACTOR: Defense

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j)			
		A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .4	S_1 National Security: Direct Military	-8	-5	-3	+9
R_2 .2	S_2 National Security: Indirect Military	-5	0	0	+8
R_3 /2	S_3 Economic/Trade	+3	+2	+1	-3
R_4 .1	S_4 Political: Domestic	+2	0	0	-6
R_5 .1	S_5 Political: Foreign	+2	0	0	-5
$\Sigma R_i = 1$	Decision Criteria: Expected Value	-3.2	-1.6	-1.0	+3.5

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Foreign Availability
4. Domestic employment

HIGH TECHNOLOGY TRANSFER CASE: Dresser Industries

ACTOR: State

Risk Factors (R_i)	Events or Impacts (S_i)	Alternatives or Choices (A_j) A_1 Approve Transfer	A_2 Restrict Transfer	A_3 Delay Transfer	A_4 Deny Transfer
		Payoffs (P_{ij})			
R_1 .1	S_1 National Security: Direct Military	-.2	-.1	0	+.5
R_2 .3	S_2 National Security: Indirect Military	-7	-5	+2	+7
R_3 .4	S_3 Economic/Trade	+8	+5	-2	-8
R_4 .1	S_4 Political: Domestic	0	-.1	-.2	-.3
R_5 .1	S_5 Political: Foreign	+.5	+.3	-.2	-.5
$\Sigma R_i = 1$	Decision Criteria: Expected Value	+1.4	+.6	-.6	-2.1

Evaluation Factors:

1. Improve existing technology
2. Manufacturing capability
3. Revolutionary change
4. Foreign availability
5. Economic cost and benefit
6. Domestic employment
7. Prestige and world leadership

PROPOSED DISTRIBUTION

Defense Intelligence Agency
DT-ID
ATTN: Mr. W. Grant d
Washington, D.C. 203

HQ, Department of The Army
ATTN: DAM-CIS
Washington, D.C. 20310

National Security Council
ATTN: Dr. G.W. Weiss, Jr.
Old Executive Building, Room 365
Washington, D.C. 20506

U.S. Army Foreign Science and Technolo
ATTN: Mr. J.J. Kosieivicz
Ms. Teresa Bigler
Mr. Roter Lloyd
220 - 7th Street, N.E.
Charlottesville, VA 22901

USAWC MILITARY STUDIES PROGRAM PAPER

A CONCEPTUAL DECISION METHODOLOGY
FOR
HIGH TECHNOLOGY TRANSFER ASSESSMENT

A GROUP STUDY PROJECT

by

Colonel Donald E. Carr, MS
Colonel William W. Cox, SC
Lieutenant Colonel Fred A. Sharp, SC

Lieutenant Colonel Theodore J. Crackel, AR
Study Adviser

US Army War College
Carlisle Barracks, Pennsylvania 17013
14 May 1982

MAY 1982

A CONCEPTUAL DECISION METHODOLOGY FOR

HIGH TECHNOLOGY TRANSFER ASSESSMENT

by

COLONEL DONALD E. CARR, MS
COLONEL WILLIAM W. COX, SC
LIEUTENANT COLONEL FRED A. SHARP, SC

APPENDIX 4

TRIP SUMMARY BRIEFS

VISIT TO U.S. ARMY FOREIGN SCIENCE & TECHNOLOGY CENTER

1. Place visited: U.S. Army Foreign Science and Technology Center
   Charlottesville, Virginia
2. Dates: 25-26 March 1982
3. Purpose of visit: To consult with the staff on matters relating to technology transfer and the decision process
4. Clearance required: Yes (in advance, SSO channels)
5. Offices and Individuals visited:

John J. Kosiewicz	AV 274-7427
Chief, Nuclear & Physical Science Branch	
Teresa Bigler	AV 274-7661
Robert Lloyd	
Chief, S & T Estimates Branch	

6. Summary of visit:

Arrived afternoon 25 March and arranged with our POC the areas of interest and offices to visit. 26 March initial visit was with members of the Sciences Division. We laid out our project for them and discussed in detail various aspects, both pro and con. The initial reaction was mixed, however; as we got into it and further discussion took place, we found out that many changes have taken place regarding the current administration's process for dealing with technology transfer. Those in attendance also found out where we were coming from; they then began to look more positively

at our project. Conclusion was: it just might be the right time for something like this. We received several references from the group to review and were provided the history of current changes reference TTIC and several offices and names for possible consultation with reference to our project.

Our next visit was with the Commander of the Center. He welcomed us and we briefly covered the purpose of our visit with his agency. He encouraged us to use the knowledge and resources of his Center and to tell others about it.

The afternoon was spent consulting with the Chief of Science and Technology Estimates. We received a briefing on Russian Design Development and Production Process and discussed how they used what they get from the U.S. in the way of technology transfer. Their motto: "Think poor, make it simple, do the job at a given point in time." It is key today to know what the Soviet technology targets are in the U.S. and zero in on them; it sames time and resources.

Our last visit for the afternoon was with Mr. Bob Lloyd, where we got with another analyst and went over our model and factors with them. We exchanged ideas and they provided some suggestions and areas where we might consider changing our approach. Their experience was very valuable in the review. We concluded our visit late afternoon with our POC, MAJ Dick Ely.

7. Significant Points:

a. The complete area of technology transfer is currently in a state of dynamic change.

b. It was recommended that we visit and discuss our MSP project with TTIC and other interested DoD agencies.

c. The U.S. focus needs to be on Soviet technical targets. They represent saving in time and resources to this nation.

d. This model concept represents a tool that could be used in a wide range of decision processes on issues of national interest.

e. Governmental changes presently taking place with impact directly on the decision process as it relates to technology transfer and national security.

f. It is a good time to propose a decision model concept of this nature, the interest level is high in the current administration and changes taking place within the government can make use of a concept of this nature.

g. Several additional reference sources were provided by those consulted at the Center.

VISIT TO WASHINGTON, D.C. AGENCIES

1. Place visited: Washington, D.C.
    a. Defense Intelligence Agency (DIA)
    b. Department of The Army (DA) - Pentagon
    c. National Security Council (NSC) - Old Executive Bld.
2. Dates: 5-6 April 1982
3. Purpose of visit: To consult and discuss MSP project with individual agencies of DA, DoD, and NSC who are involved in the management and decision making process as it relates to technology transfer
4. Clearance required: Yes (in advance, SSO channels)
5. Offices and Individuals visited:

reviewing items within items or processes associated or how they are assembled, etc., and often times the technical expertise is lacking and things slip through. A review of the organization they work within was discussed. They reviewed the factors we had developed for our project model concept and proved some recommeded considerations from their experience. They also suggested that we visit both the Navy and the Air Force offices responbile for technology transfer, since each handles it differently from each other as well as differently from the Army. All of them from a service standpoint must get involved with the transfer decision process within DoD. It was also recommended that we touch base with the Office of DCSLOG. The meeting was concluded and each offered to provide any assistance they could in our effort to develop this decision concept. Each office was very helpful and did provide materials for our review and use.

6 April, visited DIA, Office of Technology Transfer. Mr. Grant and Mr. Dearlove each are members of the Technology Transfer Intelligence Committee (TTIC). Each have been involved with the technology transfer area for many years and reflected an indepth knowledge of the area, specific cases, the history, the current maneuvering that is going on relating to the control process, and the many key players involved. They were quick to point out that technology transfer is such a broad area and everyone seems to be working their own individual area, and thus no one really has a handle on the total process. That it may never be controlled in its entirety, but certainly can be made more manageable. In many cases the data is available on a given item, project, etc., but has never been screened for technology transfer. Data bases have not been established, thus adding to the problems

LTC Charles Parker	2D481
MAJ Joe Angsten	OCSA 202-697-6604
Mr. Mr. Walt E. Grant	DIA 202-694-8235
Mr. James W. Dearlove	DIA (DT-ID) AV 224-8235
Dr. Gus W. Weiss	National Security Council Advisor

6. Summary of visit:

5 April, arrived Washington and visited with the offices of LTC Charles Parker, DACSI, DA and MAJ Joe Angsten, Staff Management Director, OCSA, who works actions involving technology transfer as it relates to military sales. After explanation of our project, each provided some insight as to where they fit into the technology transfer process. They pointed out that within the Army there exists a mixture of different offices being involved in a transfer action. They referenced AR 12-1, 70-57, 70-75 and CSR 5-2 as regulations they use and the fact that DCSLOG has military sales responsibilities and all that goes with that responsibility. LTC Parker also indicated that he had been involved in this area on a previous assignment, but even with that, it is difficult to stay on top of this area. It is so broad, diversified and has such a complex array of different agencies within the government involved that many times even though they should be involved they are by-passes or because of the time element they are not asked or are contacted direct for input when the request should be coming through channels. There are just so many aspects involved in reviewing cases that no one individual or even several can be the expert on all areas: it's a real problem. Within the framework of the Army staff for review of technology transfer issues or cases, the critical list published by the Office of the Secretary of Defense is used; however, often it requires

associated with attempting to manage such an area. The politics associated often are very intense and at very high levels. Technical expertise is lacking within the government in many areas associated with specifics of products, processes, etc., involving transfer and must be gotten outside the responsible agencies. We discussed our project with them, and they reviewed our model concept and agreed that we should press on with it, that it could be used and could lend some possible standardization within selected areas. They recommended selected cases to us that could be used to test our model concept, provided us with selected documents for review and use and made available to us case files to use in our project. To point out the interest at attempting to standardize review of cases, they provided us with a copy of a recent memo regarding processing of U.S., COCOM, and Munitions Control Export cases (Incl 1). They also recommended that we maintain our clearance with them and return to go over the files made available. It was suggested that we contact COL Bob Witter, OX7-1327 and discuss our project with him, since he is involved in this area.

The visit with NSC, Dr. Gus W. Weiss went very well. He, too, again pointed out that the area of technology transfer is a broad, complex subject, often elusive and no one individual possesses the expertise in the many areas associated with the many cases or decisions involving transfer decisions. That the process is most always very time-sensitive and critical, that evaluation factors are always most difficult to establish and apply and every case that reaches his level is different. After reviewing our concept, he indicated that models had been used in the past in many of the analyses he conduced. He encouraged us to continue the project and provided us with a case study he had written. He also made recommendations

on cases to use in our analysis of our model concept. The committee which he heads is now taking an active part in the review process of selected high level technology transfer cases. He also acknowledged that a need exists for a common data base, but because the area is so broad and diversified involving so many different agencies, both within the government and the private sector, that to put one in operation is nearly impossible. We concluded our visit and returned to Carlisle.

7. Significant Points:

a. DIA indicated that we must narrow our focus to targeted requirements from the Soviet Block and Third World.

b. The U.S. needs to focus its attention on unique U.S. capabilities. This, then, will reduce the scope and resources required to combat loss of technology transfer. (DIA)

c. No common data base exists within the governing agency, what exists is fragmented, narrow in scope and incomplete. (DIA, NSC, DA)

d. Agencies must begin to look at technology transfer in a systems approach pattern, otherwise we will continue to loose valuable capabilities through bits and pieces which are extracted and combined by our foes into use on other weapon systems. (DIA and NSC)

e. The U.S. must know and consider in the decision process the packaging and manufacturing capabilities of the nation under consideration for a given technology transfer. It must be projected out with the capability of the proposed transfer of knowledge. (DIA)

f. Confusion exists on the Army Staff as to who is responsible for what in the area of technology transfer. (DA)

g. The issue of technology transfer, although not new, is now a very

visible area with a lot of agencies procuring resources to get in on the current surge of interest. (DIA, DA, NSC)

h. The area of technology transfer is such a broad area and within the federal agencies everyone is working their own area--no one is managing the total process. (DIA)

i. The politics associated with technology transfer cases often become very intense. (DA, DIA, NSC)

j. High level decisions involving critical technology transfer in most cases is a collected effort and is time sensitive. (NSC)

k. There are attempts being made to standardize review of cases within the federal agencies. (See Incl 1)